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Comment Barry K. Goodwin

I am pleased to have this opportunity to comment on the excellent chapter of Enders and Holt. As is typical of the work of these two researchers, the chapter represents the "leading edge" in time-series analysis of important commodity price relationships. In this case, it is the linkages among energy and agricultural commodity markets that are the focus of the analysis. The relationships among these markets has become a critical issue in applied price analysis, particularly since 2007, when the Energy Independence and Security Act of 2007 (Pub.L. 110-140) was passed. Among other important changes, this legislation significantly increased the mandated amount of

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biofuels that must be added to gasoline (i.e., the Renewable Fuels Standard) from 4.7 billion gallons in 2007 to 36 billion gallons by 2022. This legislative change, taken together with significant increases in worldwide demand for fuel, has brought about unprecedented volatility and high prices for agricultural commodities. The authors acknowledge the important impact of the biofuels policy as well as significant income growth in the "BRIC" countries of Brazil, Russia, India, and China, which served to stimulate the demand for fuels worldwide. The analysis is very competently executed and the results are compelling. I have little to offer in the way of critical comments but rather intend for my comments to serve as a catalyst for further inquiry.

The analysis of Enders and Holt consists of two nonstructural time-series models. The models are not as tightly linked as one might prefer. The first model consists of a standard vector autoregressive (VAR) model containing composite indexes of grain and energy prices, along with real exchange rates and the real rate of interest. The real rate of interest is calculated using changes in the US consumer price index (CPI) while prices are deflated using the US producer price index (PPI). This transformation of the data to place values in real terms raises two important questions. First, it is not clear why two different price indexes—indexes that tend to be very different from one another—are used in a single model to adjust for inflation. This raises a related question about which index is appropriate for deflating agricultural and energy prices. This is a fundamental question for which a precise answer that all can agree on is elusive. Agricultural prices have shown a long-run downward trend, reflecting significant structural changes in both supply and demand. Deflating such trending prices presents challenges since it often results in historical prices being inflated to unreasonably high levels. This is especially true of the CPI, which has risen much faster than has been the case for many basic commodities, including agricultural products. Thus, a second important question pertains to whether it is most appropriate to deflate prices. The real prices are utilized in a logarithmic form in the VAR models and thus deflation is somewhat analogous to including the deflator as a regressor in the model, albeit with a restricted coefficient. While it is true that the inclusion of interest rates and exchange rates complicates this straightforward interpretation, a more flexible approach would be to simply include the appropriate deflator as a regressor in the VAR model and work with nominal prices.

Inferences are drawn from the VAR estimates by applying a specific Choleski decomposition that imposes a set Granger causality structure on the relationships. Although the ordering is supported by specification tests, one may raise questions about some of the restrictions that are imposed. For example, the specification only allows for contemporaneous impacts of real energy, real exchange rate, and real T-bill shocks on grain prices and real interest rate shocks on real exchange rates. One may wonder why, for example, energy prices are not contemporaneously impacted by exchange rate and interest rate shocks. The VAR models serve to highlight important dynamic relationships among agricultural and energy prices and serve as an introduction to a more detailed VAR model with structural breaks.

The more substantial part of the analysis comes from a shifting-mean or SM-VAR analysis. The analysis models the mean values of the variables as a flexible function of t by including multiple mean-shifting functions $g(t)$. A different set of variables is included in this segment of the analysis—maize, soy, and crude oil prices, a measure of ocean freight transport costs, and the price of ethanol. Again, the variables are deflated using the PPI and the aforementioned suggestion of simply including the PPI as a regressor in the model seems particularly appropriate here. Likewise, the link between the two different empirical models is tenuous since such different variables are included in the models. The measure of ocean freight rates is intended to be an indicator of overall global economic activity and has been used within this context before (see, for example, Kilian 2009). Ethanol has played a major role in the ongoing biofuels debate, with approximately 40 percent of US corn now going toward ethanol production. Corn prices and acreage have reached all-time highs and many attribute these structural shifts in the corn market directly to the biofuels mandate. The model also includes a measure of weather shocks that is derived from the National Climatic Data Center's climate extreme index (CEI) for the Upper Midwest climate region.

That weather shocks have important impacts on agricultural markets is beyond debate. However, one must question this specific measure of weather impacts on prices for goods heavily traded in the global economy. The climate index applies to a particularly narrow region of the overall area of production of corn and competing crops and it is thus not surprising that the measure turns out to have little significant relationship with commodity prices. Although the impacts of weather on crop yields and thus prices tends to be systemic, a more global measure of weather-related yield shocks may be more appropriate.

A central goal of the analysis is to identify and characterize structural shifts among these commodities. To this end, the authors employ a rich and flexible approach to including multiple mean-shifting functions in the VAR models. This approach follows a long progression of the development of time-series methods for identifying and capturing the effects of structural changes in empirical models. The basic approach is familiar to any undergraduate econometrics student. For known break points, the data are divided at the discrete break and the fit of the model is compared to one without any such break. The familiar "Chow" (Chow 1960) test allows standard inferential techniques to be applied in order to determine the significance of any such structural break. This approach works well when knowledge of the institutional setting underlying the empirical model suggests a particular break. However, the problem becomes more problematic when the timing and number of break points is unknown. A common approach long applied in the empirical literature is to search over numerous break points and then to select the most significant Chow test statistics in order to identify the timing of the discrete break. However, as Andrews (1993) and Hansen (1992) have noted, such an approach leads to nonstandard inferential problems of the sort identified by Davies (1977). Because the test statistic is a supremum and because parameters associated with alternative regimes are unobserved under the null hypothesis of no break, it does not have a standard F or χ^2 distribution. Andrews (1993) and Hansen (1992) have developed alternative test statistics that overcome this problem, either through the use of limiting distributions or simulated critical values of the test statistics. Other approaches to testing for structural breaks with unknown join points have been developed within the context of cumulative sums or sums of squares (CUSUM) tests by Brown, Durbin, and Evans (1975) and Ploberger and Krämer (1992). These approaches have been generalized to the case of multiple discrete breaks with unknown join points by Bai and Perron (1998).

In contrast to discrete breaks, structural change often occurs at a gradual pace. To accommodate such graduate changes, specifications and inferential procedures that utilize gradual shifting means have been developed. For example, Lin and Teräsvirta (1994) have developed "transition functions" that specify a function of t that is allowed to shift gradually. Thus, a time-shifting mean may be written as $g(t) = g_0 * G(\eta, \tau) + (1 - G(\eta, \tau)) * g_1$, where $G(\cdot)$ is a function that is bounded between (0,1) and η and τ are parameters that identify the timing and speed of adjustment between regimes. Popular choices for $G(\cdot)$ include exponential and logistic functions. Depending on the specification of the transition function, a change may be transitory (either symmetric or asymmetric) or permanent. Multiple transition functions may be included in the regression model so as to allow for considerable flexibility that includes multiple, overlapping structural shifts. This is the approach that Enders and Holt adopt and I believe it offers a strong method of representing structural breaks that is conceptually sound. One feature that I find particularly appealing is the manner in which mean shifts, which contemporaneously impact only the equation in which they appear, are allowed to impact other variables in the system through lags. Enders and Holt pursue a very innovative approach to isolating the effects of each mean shift in the system. Their graphical analysis provides important insights into the dynamics of each individual mean shift across the system.

I believe that this literature, from simple Chow tests of known break points to more sophisticated models with multiple, gradual structural shifts, represents a natural progression of the science of modeling structural breaks. Each successive specification allows for greater flexibility in representing structural change, albeit at the cost of additional parameters to be estimated and greater complexity in the nonlinearities of the estimation problem. Two observations seem relevant. First, we do in fact know the timing of many of the events thought to coincide with the structural changes being modeled. For example, we have strong prior suspicions that the Energy Independence Act of 2007 played a major causal role in bringing about structural changes in the underlying economic relationships characterizing agricultural and energy markets. To the extent that such information may be used in specifying the tests, greater statistical efficiency and a more precise evaluation of the specific event in question—the energy legislation—may be possible. Knowing the timing of the suspected change a priori also circumvents many of the complications associated with nonstandard approaches to testing.

A second thought pertains to taking this natural progression of flexible specifications to its natural end—a fully nonparametric representation of a shifting mean. Recent advances in semiparametric modeling have included methods for additive models that consist of a mixture of parametric and nonparametric components. An example can be found in the "generalized additive models" of Hastie and Tibshirani (1986) and Linton (2000). Backfitting and integration algorithms are available for estimating such models. Such methods can be amended to impose specific conditions such as monotonicity and concavity. Though technical hurdles may exist, this seems to be a promising avenue for future research in this area and represents a natural next step in specifying more flexible models.

Finally, a few minor suggestions that may be relevant for future work in this area are appropriate. A key variable in modeling price dynamics, particularly since 2007, is the ratio of stocks to use. Stocks have reached historically low levels and there may be some merit in including stocks in the VAR model. Likewise, corn, soy, and energy prices all have strongly seasonal deterministic components. The omission of these components may confound identification of the structural breaks that are the focus of the chapter.

Perhaps my biggest quibble with the chapter, though one that I am entirely sympathetic to, lies in the assertion made in the first line of the abstract that "we identify the key factors responsible for the general run-up of US grain prices." I would argue that in strict terms, this is not really the case. Rather, the models identify the timing and speed of adjustment but not the structural factors responsible for the changes. As a result, inferences that attempt to identify the causal relationships driving structural changes are more anecdotal in nature and generally involve an informal assessment (i.e., by "eyeballing" the results) of the structural factors that actually underlie the changes that are identified. In spite of such limitations, the results provide valuable insights into the timing and characteristics of structural shifts that can be weighed against the observable shifts that coincided with the changes. As I note, I am certainly sympathetic to this approach to modeling and such a criticism is rather banal as it goes with the territory of nonstructural time-series modeling—an approach that I often adopt and thus any such criticisms are also applicable to my own research. That said, the structural versus nonstructural debate will continue and one must always be sensitive to the strengths and shortcomings of both.

In summary, this is an outstanding chapter by two leading applied time-series econometricians. The focus on biofuels and energy impacts on commodity markets is timely and the results contribute significantly to our understanding of structural shifts in the markets that have been impacted by the policies and by other exogenous factors. As always, their work is meticulous and is exceptionally well executed. While I have identified modest suggestions for additional research, I believe this chapter makes important contributions to knowledge—both in terms of the innovative methods applied and in the empirical results that emerge from the analysis.

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